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OBSERVATIONS

OF A

QUINTUPLE BELT ON THE PLANET SATURN:

ALSO,

AN ACCOUNT OF SOME PARTICULARS OBSERVED DURING THE LATE ECLIPSE OF THE SUN:

AND ALSO,

ON THE ROTATION OF THE PLANET SATURN UPON ITS AXIS.

BY

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FROM THE

PHILOSOPHICAL TRANSACTIONS.

*67-752 a (III, 5)

No. 32

OBSERVATIONS, &c.

Read before the ROYAL SOCIETY, *December* 19, 1793.

EVERY analogy that can be traced in the appearance of the planets, seems to throw some additional light on what we know of them already. In some of my former papers I have established the spheroidical form of the planet Saturn, and pointed out the motion of a spot on its disk. From the first of these may be inferred a considerable rotation on its axis; while the latter goes a step farther, and shews that it has such a motion. My late observations seem to hint to us, that the period in which it revolves is, probably, not of a long duration.

They are as follows:

Nov. 11, 1793. 3^h 35′, 7-feet reflector, power 287.

Close to the ring of Saturn, where it passes across the body of the planet, is the shadow of the ring; very narrow, and black. See Tab. VI. fig. 1.

Immediately south of the shadow is a bright, uniform, and broad belt.

Close to this bright belt is a broad, darker belt; which is divided by two narrow, white streaks; so that by this means, it becomes to be five belts; namely, three dark, and two bright ones; the colour of the dark belt is yellowish.

The space from the quintuple belt towards the south pole of the planet which is in view, is of a pale, whitish colour; less bright than the white equatorial belt, and much less so than the ring.

The globular form of Saturn is very visible, so that it has by no means the appearance of a flat disk.

Nov. 13, 3^h 30′. The quintuple belt on Saturn is as it was Nov. 11. I saw it three hours ago, and several times since, without any visible change.

Nov. 19, 3^h 14′. The southern belt of Saturn is still divided into five. The evening is not clear enough to observe changes in it, if there were any.

Nov. 22, 2^h 32′. The quintuple belt on Saturn remains still the same; power 287.

With 430, I see the same very distinctly, but the small divisions have hardly light enough when so much magnified.

I viewed the same belt with four different object specula. One of them shewed the divisions uncommonly well.

Dec. 3, 0^h 35′. 7-feet reflector; power 287. The quintuple belt upon Saturn remains as it was Nov. 22.

I tried several double and plano-concave eye-glasses, but found them all defective in figure except one, and that being of one inch focal length, the power was too low to expect seeing these belts well with it.

The smallness of the field of view, with astronomical objects is not so disagreeable as it is generally supposed to be; for the eye may have a motion before the lens, and by that means a small luminous object, when all the rest of the field is dark, and while the telescope remains in the same situation, may be seen for as long a time, passing through the field of a concave eye-glass, as it can in a convex one; whereas with the latter, it is well known that such a motion of the eye can be of no use.

2h 36′. 20-feet reflector; power 157, 300, 480. I see the quintuple belt very well.

We know that the planet Jupiter has many belts. Some remarkable instances of their being very numerous are recorded in my journal, one of which is accompanied with a figure. The observations are as follows:

May 28, 1780. Jupiter's belts are curved; and there are a multitude of them all over the body of the planet. See fig. 2.

Jan. 18, 1790. I viewed Jupiter with the 40-feet reflector. There were two very dark, broad belts, divided by an equatorial zone or space, the colour of which was of a yellow cast. Next to the dark belts, on each side, towards the poles, were bright and dark small belts, alternately placed, and continued almost up to the poles, both ways.

In taking out fig. 2. from my journal, I perceive one so very unlike it just before, that I am induced to give it here, though rather foreign to my present purpose. It contains, however, an observation which it will not be amiss to record.

April 6, 1780. I had a fine view of Jupiter, and saw, as soon as I looked into the telescope, without having any previous notice of it, the shadow of the 3d satellite, and the satellite itself, upon the lower part of the disk. See fig. 3. The shadow was so black and well defined, that I attempted to measure it, and found its diameter by the micrometer 1″,562.

This measure of the shadow should be checked by the following observation.

March 15, 1792. 11h 54′. With the 20-feet reflector, and a power of 800, I estimate the apparent diameter of the largest of Jupiter's satellites to be less than one-fourth of the diameter of the GEORGIAN planet, which I have just been viewing. With 1200, it seems also to be less, in the same proportion. With 2400, I can plainly perceive the disk of the satellite. With 4800, the apparent diameter of the largest of the satellites is less than one-quarter of that of the GEORGIAN planet.

The analogy alluded to in the first paragraph of this paper, refers to the numerous parallel belts which we have noticed, in the above given observations, on the disks of Jupiter and Saturn.

That belts are immediately connected with the rotation of the planets will hardly be denied, when those of Jupiter are so well known always to lie in the direction of its equatorial motion. Since, then, it appears that the belts of Saturn are very numerous, like those of Jupiter, and are also placed in the direction of the longest diameter of the planet, it may not be without some reason that we infer the period of the rotation of the former to be short, like that of the latter.

The planet Mars, in all my observations, never presented itself with any parallel belts, nor do we observe such phænomena on the disk of Venus. The first is known to have a rotation much slower than Jupiter; * and the latter, according to the accounts of CASSINI and BIANCHINI, is certainly not one that moves quickly upon its axis.

However, I do not mean to enter into the strength of an argument for a quick rotation of Saturn, that may be drawn from the condition of its belts. The circumstance of a quin-

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* See Phil. Trans. Vol. LXXI. Part I. page 134.

tuple belt, is adduced here with no other view, than merely to point out an analogy in the condition of the two largest planets of our system; and from thence to infer, that every conclusion on the atmosphere and rotation of the one, drawn from the appearance of its belts, will equally apply to the other.

Slough, near Windsor,
Dec. 14, 1793.

WM. HERSCHEL.

No. 33

AN ACCOUNT, &c.

Read before the ROYAL SOCIETY, *January* 9, 1794.

It will be proper to remark that my attention, in observing this eclipse, was not directed to the time of the several particulars which are usually noticed in phænomena of this kind; such as the beginning, the end, and the digits eclipsed. I was very well assured that the care of other astronomers would render my endeavours, in that respect, perfectly unnecessary. The only view I had was, to avail myself of the power and distinctness of my telescopes, in order to see whether any appearances would arise that might deserve to be recorded; and the following particulars will, at least, serve to point out the way for similar observations to be made in other eclipses, where different circumstances may chance to afford an opportunity for gathering some addition to our knowledge, with regard to the nature and condition of the moon, or of the sun, and perhaps of both these heavenly bodies.

Sept. 5, 1793. $8^h\ 40'\ 3''$ by the clock.* My attention being directed to the place where I supposed the first impression would be made, I perceived two mountains of the moon enter the disk of the sun, as delineated at *a*, *b*, fig. 1, Tab. VII. The time of their beginning to appear, when I saw them first, might be one or two seconds past.

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* By account, my sidereal time-piece was about $5'\ 1'',7$ too forward; but, as no transits had been lately taken, there may be an error of some seconds.

$9^h 5'$. 7-feet reflector; power 287. The internal, luminous angle made on the sun, by the intersection of the limb of the moon, which is now but little more than a rectangle, is perfectly sharp up to the very point. It is not in the least disfigured by the refraction of the lunar atmosphere. The present shape of the angle, however, is not favourable for shewing the effects of that atmosphere.

$9^h 17'$. The luminous angles of the sun's preceding and following limbs, which are now acute, remain perfectly sharp. One of them, indeed, was disfigured, a little while ago, by the entrance of a mountain of the moon, but is now restored to its sharpness.

$10^h 5'$. I delineated the appearance of the limb of the moon upon the sun, and found its mountains as in fig. 2. At *a* was a large *table mountain*, as it may be called, from its flat appearance; at *b* and *c* were elevated, pointed rocks. Their appearance changing pretty fast, no great accuracy can be expected in their expressed relative situation.

I suppose the height of the most elevated of these mountains not to exceed a mile and an half; for, on drawing several of them upon the segment of a large circle, so as to look like what they appeared when projected upon the sun, I found them to be from the 1500dth to the 2000dth part of the diameter of that circle. Then, putting the moon's diameter, as M. DE LA LANDE states it, at 782 French leagues, or 2151 English miles, we find the 1500dth part of this to be less than one mile and an half for the highest; and the 2000dth part, not quite one mile and a tenth for the lowest.

I attended all this time to the appearance of the sharp limb *a b c* of the sun, fig. 3, and suspected, sometimes, a little bending of the cusps outwards, as expressed at *b* in fig. 4; but upon long, and attentive inspection, I could not satisfy myself of its reality. If there was a bending, it did probably not amount to one second of a degree; for, having formerly been much in the habit of measuring the moon's mountains,* the quantity of one second, on its disk, was still familiar enough to me to estimate it pretty exactly.

10ʰ 15′. I looked out with the natural eye for the planet Venus, and soon perceived her. In the telescope, with 287, she appeared very sharp and well defined, and was a little gibbous.

It may seem, perhaps, extraordinary that in the trial above mentioned, the eye should be able to ascertain the proportion of a quantity so little as the fifteen hundredth, or two thousandth part of the diameter of the moon; but the experiment may be easily repeated in the following manner:

Upon a line, six or eight inches long, drawn on a sheet of paper, make several small marks, representing mountains on the projected circumference of a large globe. The paper being then placed in a proper light and situation, withdraw the eye to the distance of 7, 8, or 9 feet, and take notice which of the marks appear of the same size, and distinctness, with the mountains they represent. Then, from the known angular magnitude of the moon, calculate its diameter, at the distance of your situation; this, multiplied by the power of the telescope, gives the diameter of a circle, to the circumference of which belongs the line, upon which are placed the marks above described. Now, measure the elevation of these marks, above that line, and you will obtain the proportion they bear to the diameter of the circle.

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* In the years 1779, 1780, and 1781. I did not measure, I suppose, less than an hundred mountains of the moon, in which I used three different methods: the projection of the tops of these mountains beyond the enlightened part of the disk; the length of their shadow on the surface of the moon; and their perpendicular projection on the full edge of the moon's limb. Some of these observations are contained in a former paper (see Phil. Trans. Vol. LXX. Part II. page 507); but most of them remain uncalculated in my journal, till some proper opportunity.

In my experiment, I found that I could plainly see some small protuberances at 9 feet distance, which were no higher than the 50th part of an inch. Then putting the diameter of the moon at 30′, we have the sum of the logarithms of the tangent of 30′; of the power 287; and of the 50ths of an inch contained in 9 feet; which, taken from the logarithm of the diameter of the moon in miles, gives the logarithm of ,16. By which we find, that so small a mountain as the $\frac{16}{100}$dth, or not much more than the sixth part of a mile, may be perceived and estimated, by the telescope and power that was used upon this occasion; and that, consequently, the estimation of mountains, near a mile and an half high, must become a very easy task.

Slough, near Windsor,
Dec. 30, 1793.

WM. HERSCHEL.

N°. 34

ON THE ROTATION, &c.

Read before the ROYAL SOCIETY, *January* 23, 1794.

In a late paper on the multiplicity of the regular belts of the planet Saturn, I pointed out an analogy, which might lead us to surmise that it had a pretty quick rotation upon its axis; I can at present announce the reality of that rotation. The following series of observations, in which Saturn has been traced through one hundred and fifty-four revolutions of its equator, will sufficiently confirm it.

The changes in the belts of Jupiter, it is well known, are so frequent, that we find some difficulty to make our observations of them agree to within 3, 4, or 5 minutes of time; but the belts on Saturn, which I have been lately observing, seem to have undergone no very material change, during the course of the two last months; so that we may hope the period of the rotation of this planet, which will be assigned in this paper, may be looked upon as having a considerable degree of exactness.

Before we can enter into particulars, it will be necessary to give the series of observations upon which my computations have been founded. It is not sufficient to extract only those parts of them which have served for calculating the period; as the value of astronomical observations consists in having them entire; every circumstance, as it occurred, is of consequence, and facts being stubborn things, we cannot decide upon them properly till they have been entirely laid open to our view, and sufficiently scrutinized. For this purpose the observations are all extracted from the journal, in the regular order in which they were made; and here I must remark, that I purposely avoided any calculations, or even surmises, of the length of a rotation, while the observations were making; in order to be perfectly free from every bias that might mislead the eye. In this I succeeded so well, that, when I began to calculate, I mistook not less than 4 hours and ¾ in the first supposition I made; which, happening to agree extraordinarily well with four of the most pointed observations, it misled me so far, that I was very near rejecting the whole series as inconsistent, and began to think the changes in the belts to have been so frequent, and irregular, as not to fall under any kind of calculation. It will, however, soon appear that this has not been the case, and that, on the contrary, there has been more steadiness and regularity in the belts, than might well have been expected in such kind of appearances.

OBSERVATIONS ON THE BELTS OF SATURN.*

Nov. 11, 1793. 3^h 35′. (*Correction of the clock* — 7′ 27″,1).† Seven-feet reflector; power 287; new specula, uncommonly distinct.* Close to the ring of Saturn, where it passes the body of the planet, is the shadow of the ring; very narrow, and black.

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* A few of these observations have been lately given; but as they are essential to the series, I thought it better to repeat them here, than to refer to my former paper.

† My time is kept by one of SHELTON'S clocks, set now and then by equal altitudes, taken with a 12-inch BIRD'S quadrant; and checked by the passage of a set of stars over the wire of a four-feet telescope, firmly fixed to the wall of my house. By calling the correction minus, I denote, in this case, that the clock is 7′ 27″,1 too fast for true sidereal time.

Immediately south of the shadow is a bright, uniform, and broad belt.

Close to this belt is a broad, darker belt, which is divided by two narrow, white streaks; so that, by this means, it becomes to be five belts; namely, three dark, and two bright ones; the colour of the dark belt is yellowish.† (A)

The space from the quintuple belt towards the south pole of the planet which is in view, is of a pale whitish colour; less bright than the white equatorial belt, and much less so than the ring.

The globular form of Saturn is very visible, so that it has, by no means, the appearance of a flat disk.

Nov. 13. $3^h 30'$. (*Cor.* — $7' 29'',5$.) The quintuple belt on Saturn is as it was Nov. 11. I saw it three hours ago, and several times since, without any visible change. (B)

Nov. 19. $3^h 14'$. (*Cor.* — $7' 36'',8$.) The southern belt of Saturn is still divided into five; the evening is not clear enough to observe changes in it, if there were any. (C)

Nov. 22. $2^h 32'$ (*Cor.* — $7' 40'',4$.) The quintuple belt on Saturn remains still the same; power 287. (D)

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* In the course of these observations, I made 10 new object specula, and 14 small plain ones, for my 7-feet reflector; having already found, that with this instrument I had light sufficient to see the belts of Saturn completely well; and that, here, the maximum of distinctness might be much easier obtained, than where large apertures are concerned.

† The letters (A) (B) (C), (*a*) (*b*) (*c*), &c. as they occur, refer to calculations which will be given hereafter.

With 430, I see the same very distinctly; but the small divisions have hardly light enough, when so much magnified.

I viewed the same belt with four different object specula. One of them shewed the divisions uncommonly well.

Dec. 3. 0ʰ 35′. *(Cor. — 7′ 53″,8.)* The quintuple belt upon Saturn remains as it was Nov. 22. (E)

2ʰ 36′. 20-feet reflector; power 157; 300; 480. I see the quintuple belt very well.*

Dec. 4. 23ʰ 22′. *(Cor. — 7′ 55″ by a transit.)* 10-feet reflector. The quintuple belt is on Saturn, as it was last night. (F)

4ʰ 57′. 7-feet. The quintuple belt is uncommonly distinct.† The three narrow dark belts are of an equal breadth over the whole disk; the two bright belts which divide them, are also of an equal breadth throughout, but a little narrower than the dark ones. (G)

5ʰ 58′. I see the quintuple belt so clearly defined throughout all the 3 dark, and 2 bright belts, that I am apt to guess that the side which presents itself to me now is not the same which I saw in the first part of the evening; but it is not easily possible to determine whether the air might not be less clear then. I saw all other phænomena on Saturn extremely well, many times, between 1^h and 3^h; but not the belts so well as now. (H)

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* I found that the strong light of this instrument was too great a fatigue for the eye, which cannot bear to look at a very luminous object for a long time together. For this reason, I chiefly used the 7-feet reflector; and in future, all the observations, not expressly marked otherwise, are to be understood as having been made with that instrument; bearing an eye-glass of 3-tenths of an inch focal length. My object specula are generally from 84 to 88 inches in focus, and, therefore, give a power from 280 to 293. The favourite one gave 287. I had another reason for chiefly confining myself to one instrument, and one power; which was, that every circumstance being as much as possible the same, a change in the object I viewed might be the sooner perceived.

† When I found the divisions between the small belts so remarkably distinct, I began to suspect that they might not be, all around the planet, perfectly uniform in brightness and figure; and therefore now described the phænomena that occurred more minutely and carefully.

$6^h\ 36'$. The belt remains as free from interruptions as it was at $5^h\ 58'$. (I)

$6^h\ 52'$. I see the planet not so well defined now, as I did in the first part of the evening; being at present nearer the horizon; but I see the belts better than I did at that time. (K)

Dec. 6. $22^h\ 28'$ (*Cor.* — $7'\ 57'',2$.) I see the quintuple belt very distinctly. (L)

$22^h\ 55'$. I see the quintuple belt as readily as I see the rest of the appearances on Saturn. (M) I took care to bend my head so, as to receive the picture of the belt in the same direction upon the retina, as I did December 4, at $5^h\ 58'$.*

$23^h\ 55'$. I now see the quintuple belt full as well as I did Dec. 4, at $5^h\ 58'$. (N)

$1^h\ 25'$. That part of the quintuple belt which is now on the meridian, or centre of Saturn, is much less separated and defined than what was there at $23^h\ 55'$. (O)

$2^h\ 26'$. The divisions in the quintuple belt are not grown distincter, but rather more confused than they were before; I can scarcely perceive them. (P)

$3^h\ 28'$. The uppermost of the small dark belts, in that part which is on the meridian, is very faint, and the most north is rather darker than before. (Q)

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* This was a precaution that occurred to me, as there was a possibility that the vertical diameter of the retina might be more or less sensible than the horizontal one; but I had no reason afterwards to suppose that any such difference really exists.

4^h 28′. The most north of the two belts is darker, and a little broader than the most south. (R)

5^h 53′. Saturn is remarkably distinct; much more so than Dec. 4, at 5^h 58′; but the quintuple belt is less distinct than it was that evening; it has also undoubtedly a different appearance. The northern belt is the darkest and broadest, that next to it is less dark; and the third, or southmost belt, is faint, and hardly to be seen; the narrow white belts that separate them are contracted, and but just visible. (S)

OBSERVATION UPON THE DOUBLE RING OF SATURN.*

The outer ring is less bright than the inner ring. The inner ring is very bright close to the dividing space; and, at about half its breadth, it begins to change colour, gradually growing fainter; and just upon the inner edge, it is almost of the colour of the dark part of the quintuple belt.

7^h 52′. This is evidently another part of the planet than what I saw in the beginning of the evening. (T)

Dec. 9. 5^h 33′. (*Cor.* — 8′ 0″,4.) The quintuple belt is extremely distinct, but not so much so, in proportion to the rest of the appearances, as I might expect. (U)

6^h 9′. The southmost dark belt is very faint; the northmost is the strongest and broadest; the bright divisions are very small, and difficult to be seen; I can, however, trace them all along. (V)

Dec. 11. 1^h 25′. (*Cor.* — 8′ 2″,6.) I see the quintuple belt. The southmost belt is extremely faint; that to the north is the darkest and broadest; the middlemost is nearly as dark, but not quite so broad. (W) The air is much disturbed by wind, and flying haziness.

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* This observation is foreign to the present purpose, but as it is new, and but short, I would not omit it; and for the same reason, two or three more are retained hereafter.

5^h $5'$. The quintuple belt is very distinct. The southmost belt is less faint than it was at 1^h $25'$; but the wind is too high, and the air too disturbed, to examine it minutely. (X)

Dec. 13. 23^h $40'$. (*Cor.* — $8'$ $4'',7$.) I see the divisions of the quintuple belt very well; but there is a dry wind, and the telescope will not shew objects with that degree of distinctness which it usually does, when moisture is discharged from the air, by the precipitation of dew. (Y)

0^h $46'$. I see the quintuple belt very well.

REMARK ON THE SHADOWS OF SATURN AND ITS RING.

On the south following part of the ring, close to the body of the planet, is the shadow of the body.

The shadow of the ring upon the body of the planet close to the ring, is not parallel to the ring at the two extremes, but a little broader there, than in the middle; the ends turning towards the south.

2^h $4'$. The bright divisions between the belts are very narrow. The southmost dark belt is not much less faint than the northmost. (Z)

2^h $51'$. The southmost dark belt on the preceding side, which at 23^h $40'$, I thought was a little more south than the inside of the ring, now falls short of it. The broad bright belt also seems to be narrower now, than it was at that time.*

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* Suspecting that the situation and direction of the belts might not be uniform all around the planet, I began to be more careful in describing the particulars relating to those circumstances; but found, soon after, that no additional light could be gathered from an attention to them.

3h 2′. The broad bright belt, is as broad as the next three belts and a half, of the quintuple belt: that is, not quite so broad as the quintuple belt, without the southmost narrow dark belt.

4h 11′. The broad white belt is of the breadth of the three adjoining belts.

5h 11′. Appearances seem to be the same as they were an hour ago. The evening is indifferent. (*a*)

Dec. 16. 0h 43′. *(Cor. — 8′ 8″,0 by a transit.)* I see the quintuple belt extremely well.

1h 3′. The most south of the three dark belts, is full up to the inner edge of the preceding side of the ring; or rather a little above (or south of) it. The following side is less south, with regard to the ring, than the preceding; so that the quintuple belt is not parallel with that part of the ring, which crosses the body.

2h 21′. The southmost belt is very faint; the middle and northern ones are much darker, and seem to be broader and closer, than I have at other times seen them. (*b*)

With 215. This power is too small to distinguish the divisions of the quintuple belt sufficiently.

3h 12′. There seems to be no material alteration, but I do not see the divisions of the belt so distinctly as from the appearance of the other phænomena I ought to do. (*c*)

4h 5′. The southmost belt meets the inner edge of the preceding part of the ring very nearly, and the quintuple belt seems to be parallel to the northern part of the ring, or nearly so.

4h 16′. 10-feet reflector; power 300. The quintuple belt is parallel to the northern part of the ring, which is turned towards us.

5^h 35'. 7-feet. The southmost belt is brighter than it was at 2^h 21'. (*d*)

Dec. 18. 23^h 54'. (*Cor.* — 8' 9",8.) I see the quintuple belt. (*e*)

1^h 19'. All the parts of the quintuple belt seem to be very uniform. The southmost on the preceding side, reaches full up to the ring, where it passes behind the body. (*f*)

I viewed the planet with eight different object specula, they all shewed the quintuple belt very well.

Dec. 19. 1^h 41'. (*Cor.* — 8' 10",6.) I have a very beautiful view of Saturn. I should suppose this part of Saturn to be that, where the quintuple belt is not so distinct as it is on some other parts; though I see it very well; yet from the extraordinary distinctness of the other phænomena, I think I ought to see it still better. (*g*)

THE FIVE OLD SATELLITES.

1^h 56'. 10-*feet reflector*; *with a power of* 60 *only, I see all the five old satellites*.*

4^h 15'. 7-feet reflector. The southmost belt is faint The quintuple belt is a little broader on the preceding side, than on the following. (*h*)

Dec. 23. 3^h 46'. (*Cor.* — 8' 14",2.) I see the quintuple belt very distinctly. The northmost of the dark belts is the broadest and darkest; the southmost is very faint; they are parallel to the ring, and the southmost just comes up to the inner edge of the ring. (*i*)

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* This observation was made to try with how low a power they might be seen.

Dec. 29. 1^h 10′. (*Cor.* — 8′ 19″,5.) The quintuple belt remains on Saturn as it used to be; the southmost of the dark belts is faint. (*k*)

Jan. 1, 1794. 2^h 2′. (*Cor.* — 8′ 22″,1.) I see the quintuple belt very well; the southmost belt is not much fainter than the northmost. (*l*)

OBSERVATIONS OF THE SOUTH POLE OF SATURN, AND THE SHADOW OF THE RING.

3^h 40′. *The south polar regions of Saturn, are a little brighter in proportion to the bright equatorial belt, than they used to be; they are almost as bright as that belt.*

The shadow of the ring upon Saturn is perfectly black, like the shadow of Saturn upon the ring. The shadow of the ring upon Saturn, on each side, is bent a little southwards; so that the apparent curve it makes departs a little from the ring.

5^h 18′. The three dark belts of the quintuple belt seem to be very close, but the air is tremulous; I can however see them divided. (*m*)

Jan. 2. 23^h 53′. (*Cor.* — 8′ 23″,0 *by a transit.*) The quintuple belt is very distinct. The southmost belt is almost as dark as the other two. (*n*)

1^h 52′. The southmost belt is very nearly, if not quite as dark and distinct as the northmost. The air is very fine, and all the phænomena on Saturn are beautifully distinct. (*o*)

Jan. 4. 1^h 36′. (*Cor.* — 8′ 23″,8.) The quintuple belt is not so distinct as, from the appearance of the rest of the phænomena on Saturn, one might expect to see it. All the three dark belts are fainter than I have often seen them; and the southmost of them is much fainter than the northmost. (*p*)

2^h 35′. The quintuple belt is still faint. The southmost belt much fainter than the northmost; the latter is not only stronger, but also broader than the former. (*q*)

Jan. 7. 1^h 4′. (*Cor.* — 8′ 25″,0 *by a transit.*) The three dark belts of the quintuple belt, seem not to differ much in colour and breadth, but the evening is very indifferent. (*r*)

1^h 53′. The air is a little clearer. The southmost is very little (if at all) less dark than the northmost; they are all very faint. (*s*)

3^h 18′. As well as the night will permit to see, I judge the dark belts to be pretty equal in colour and size, the northmost, however, is still a little darker, and broader than the other two. (*t*)

3^h 44′. The dark belts seem to be as equal as I have seen them at any time. I see them very well. (*u*)

TRIAL OF CONCAVE EYE GLASSES.

I tried five new concave eye glasses, but they all proved defective in figure; with one of them, power 360, I saw the quintuple belt pretty well. With regard to the field of view they are full as convenient as convex glasses. (*v*)

5^h 50′. The three dark belts are still nearly alike, and uniformly divided by the bright ones. (*w*)

Jan. 16. 2^h 52′. (*Cor.* — 8′ 28″,6.) I suppose this to be the part of the quintuple belt, which is nearly uniform; the southmost one however is not quite so dark as the northmost. (*x*)

4^h 20′. The belts seem to be equal and uniform throughout. (*y*)

5^h 5′. The belts seem to be uniform; the southmost however is the faintest. (*z*)

DETERMINATION OF THE PERIOD.

I shall now enter upon the method, which has been used to determine the rotation of the planet, from these observations.

Let K, T, Z, P, in the annexed figure, (see Tab. IX.) represent the quintuple belt on the southern hemisphere of Saturn; the different parts of which are diversified as expressed by the different tints of the belts: those at E A K N I H M L G being uniform, while others at T B C D V, and R Q Y F have the southmost of the small dark belts very faint, and the northmost pretty strongly marked. Let α be the south pole of Saturn, and let the circle 90, 180, 270, 360 represent its equator, divided into degrees; so that α 180, α 210, α 240, α 270, &c. are meridians of Saturn, which, as the planet turns upon its axis, from west to east, will successively pass over the line α β γ, representing that meridian on Saturn which passes through the earth.

Then the eye of the observer being placed in the line α β γ, at a great distance, and the hemisphere of Saturn, which is here projected on the plane of the equator, being in an oblique position, will only see the semicircle δ β ε. But on account of the great inclination of the arches ζ δ, η ε, to the visual ray γ β α, the eye will not perceive minute divisions, or marks, till they come within the limits ζ η, and even then will no where judge so well of their brightness and figure as when they draw near the situation β.

The divisions on the equator, are to serve us to point out those places of the quintuple belt, which, by future calculations of the motion of this equator, will be shewn to have been on the meridian, α β γ, at any given time; and the numbers are placed in the reverse order of the rotation, that the calculated motion of the belt may immediately point out the place which is come to the meridian. Thus, if the point K at 180 has moved 53 degrees forward, the situation x, on the belt, may be concluded to be on the meridian; because it is at 180 + 53, that is, the 233d degree.

Assuming for an epoch the observation of Dec. 4. 4^h 57′, where the different small belts, that make up the quintuple belt, are described as quite uniform; let it be placed at the 180th degree of the divided circle, where it will be fully exposed to the view of the observer.

I now select a few observations that are strongly marked, and as far distant from each other as can be found, by way of trying in what rotation they will agree. Such are the following two: Dec. 4. 6^h 52′; Jan. 7. 3^h 44′, for the places where the belts were uniform; and other two, Dec. 6. 7^h 52′, Jan. 4. 2^h 35′, for places where they appeared unequal. The sidereal times being corrected, and brought to true mean time we have from Dec. 4. 13^h 46′ 51″, to Jan. 7. 8^h 25′ 11″ an interval of 33 days 18^h 38′ 20″; in which time let us suppose 79 revolutions to have been made. This will give 10^h 15′ 40″ for the time of each revolution.

In the next place, we have from Dec. 6. 14^h 38′47″ to Jan. 4. 7^h 28′ 12″ an interval of 28 days 16^h 49′ 25″; and allotting 67 revolutions to this, we obtain 10^h 16′ 51″ for the time of the rotation. These periods being independent of each other, and the observations having been made upon different parts of the belt, agree very well together. But now, some intermediate places are wanted, by way of trying, whether the period thus determined will accord with the rest of the observations; and for this purpose I select Dec. 18. 1ʰ 19′, Jan. 2. 1ʰ 52′; and bringing them also to true mean time, we have,

From Dec. 4. 13ʰ 46′ 51″ to Dec. 18. 7ʰ 19′ 28″ an interval of 13 days 17ʰ 32′ 37″. Then, supposing 32 revolutions to have been made, we obtain a period of 10ʰ 17′ 54″. Also,

From Dec. 4. 13ʰ 46′ 51″ to Jan. 2. 6ʰ 53′ 11″ is an interval of 28 days 17ʰ 6′ 20″; and admitting 67 revolutions of the belts, the period will be 10ʰ 17′ 6″.

These trials of intermediate times agreeing with the former sufficiently well, there can remain no doubt about the true quantity of the period in general. I therefore take a mean of the two first determinations, which gives 10ʰ 16′ 15″,5 for the approximate rotation of Saturn upon its axis.

It now becomes necessary to construct tables for a general calculation of all the observations. For, if these should contain descriptions contradicting the calculated appearances of the quintuple belt, our assigned period could not be looked upon as sufficiently established; on the contrary, if the calculated and observed appearances are found to agree, we may rest satisfied that the rotatory motion of this planet, which has so long eluded our strictest attention, is at length obtained.

In consequence of a few trials, which were made after the 7th of January, by tables constructed upon this mean period, I found that some small correction was required; and obtaining another very good observation on the 16th of the same month, it gave me an interval which included one hundred revolutions of the equator of Saturn. Now, making the proper deduction for the planet's retrograde motion during the time that passed between the first and last observation, we have from Dec. 4. 13ʰ 46′ 51″ to Jan. 16. 8ʰ 25′ 39″ an interval of 42 days

18h 38′ 48″ in which the equator of Saturn moved over 35998,87 degrees, from which we compute a period of 10h 16′ 0″,44.

The following tables have been constructed upon this last period, and in the use of them the complement of the geocentric longitude of Saturn is always to be added, as has been explained in the tables of the satellites of that planet. Phil. Trans. Vol. LXXX. part II. page 495.

TABLES FOR THE EQUATORIAL MOTION OF SATURN.

Epochs of the Longitude of the uniform Part of the Belts.

1793	November	-	284°,18
1793	December	-	330 ,62
1794	January	-	138 ,61.

Motion of the Equator of Saturn, in Days, Hours, Minutes, and Seconds.

Days.	Deg. dec.	Hours	Deg. dec.	Min.	Deg.dec.	Min.	Deg.dec.	Sec.	dec.	Sec.	dec.
1	121,55	1	35,06	1	,58	31	18,12	1	,01	31	,30
2	243,10	2	70,13	2	1,17	32	18,70	2	,02	32	,31
3	4,64	3	105,19	3	1,75	33	19,29	3	,03	33	,32
4	126,19	4	140,26	4	2,34	34	19,87	4	,04	34	,33
5	247,74	5	175,32	5	2,92	35	20,45	5	,05	35	,34
6	9,29	6	210,39	6	3,51	36	21,04	6	,06	36	,35
7	130,84	7	245,45	7	4,09	37	21,62	7	,07	37	,36
8	252,38	8	280,52	8	4,68	38	22,21	8	,08	38	,37
9	13,93	9	315,58	9	5,26	39	22,79	9	,09	39	,38
10	135,48	10	350,65	10	5,84	40	23,38	10	,10	40	,39
11	257,03	11	25,71	11	6,43	41	23,96	11	,11	41	,40
12	18,58	12	60,77	12	7,01	42	24,54	12	,12	42	,41
13	140,12	13	95,84	13	7,60	43	25,13	13	,13	43	,42
14	261,67	14	130,90	14	8,18	44	25,71	14	,14	44	,43
15	23,22	15	165,97	15	8,77	45	26,30	15	,15	45	,44
16	144,77	16	201,03	16	9,35	46	26,88	16	,16	46	,45
17	266,32	17	236,10	17	9,93	47	27,47	17	,16	47	,46
18	27,86	18	271,16	18	10,52	48	28,05	18	,17	48	,47
19	149,41	19	306,23	19	11,10	49	28,64	19	,18	49	,48
20	270,96	20	341,29	20	11,69	50	29,22	20	,19	50	,49
21	32,51	21	16,35	21	12,27	51	29,80	21	,20	51	,49
22	154,06	22	51,42	22	12,86	52	30,39	22	,21	52	.50
23	275,60	23	86,48	23	13,44	53	30,97	23	,22	53	,51
24	37,15	24	121,55	24	14,03	54	31,56	24	,23	54	,52
25	158,70			25	14,61	55	32,14	25	,24	55	,53
26	280,25			26	15,19	56	32,73	26	,25	56	,54
27	41,80			27	15,78	57	33,31	27	,26	57	,55
28	163,34			28	16,36	58	33,90	28	,27	58	,56
29	284,89			29	16,95	59	34,48	29	,28	59	,57
30	46,44			30	17,53	60	35,06	30	,29	60	,58
31	167,99										

The following 50 positions have been calculated by the above tables, and belong to the several observations which are marked with the tabular letters of references, as has been explained in the 2d note, page 50. They have been computed to two places of decimals, but are only put down in degrees, as being sufficiently near for comparing them with the descriptions belonging to those parts of the belt which they point out.

Table of calculated Positions.

A	201	K	180	T	94	*c*	43	*m*	225	*v*	186
B	77	L	125	U	10	*d*	127	*n*	155	*w*	239
C	63	M	141	V	31	*e*	167	*o*	224	*x*	129
D	37	N	176	W	105	*f*	216	*p*	93	*y*	180
E	201	O	228	X	233	*g*	348	*q*	128	*z*	206
F	278	P	264	Y	282	*h*	78	*r*	73		
G	113	Q	300	Z	6	*i*	178	*s*	101		
H	149	R	335	*a*	115	*k*	83	*t*	151		
I	171	S	24	*b*	14	*l*	111	*u*	166		

I may venture to say, that there are not many of these calculated observations which do not very forcibly concur in proving the assigned revolution to be properly stated. I shall however only mention a few of the leading ones, and leave the rest to be looked over at leisure by those who wish to examine the subject minutely.

In observations previous to the 4th of December, no particular attention had been given to the minutiæ of the belts; but we may suppose them, on the 11th of November, to have been considerably distinct and uniform, to occasion their being noticed; and this the calculation verifies. For the position A points out 201 degrees, as the situation which was on the meridian at the time of observation, and by the figure we find it to be a very marked place.

A strong evidence of the rotation is the position H 149, observed Dec. 4, contrasted with the place F 278, which had been viewed in the early part of the same evening. The calculation here completely supports the suspicion which is expressed in the observation, "that the side which presented "itself then was not the same which had been seen in the be"ginning of the evening."

The observations of Dec. 6, are of the most decisive nature; as will clearly appear by viewing the calculated positions L M N O P Q R S T, and comparing them with the descriptions belonging to them, that have been given in the observations. For, here the revolving belts were successively seen, in all their various tints, and the last position T was marked down as leaving no doubt of the evident rotation. By the calculation it appears that the belts had moved over 329 degrees, in the course of this evening's observation.

When the positions *c*, *d*, are compared, which were observed Dec. 16, we see that the southmost belt had acquired an additional brightness, as the observation expresses. It may not be amiss to remark upon this occasion, that brightness relates to clearness, distinctness, and easiness of vision; in opposition to faintness and confused outlines; therefore, the belt being brighter here, denotes its being more strongly marked by a deeper tint of dusky yellow, and by clearer divisions; so as to be easier perceived.

Dec. 19 furnishes a good instance of the exactness of our period; as the calculated position *g* perfectly justifies the surmise which is expressed in the observation.

Last of all, the place *y*, being truly pointed out by computation for Jan. 16, after a series of an hundred revolutions since the 4th of December, must concur in supporting our assigned period.

I shall only add one general remark, which is, that if we lengthen the time of the rotation but 2 minutes, it will throw the last observation back above 116 degrees; and if we diminish it by 2 minutes, there will arise an excess of more than 117; and, in either case, the calculations and observations would be totally at variance: from which we may conclude that our period must be exact to much less than 2 minutes, either way. Indeed, what alterations may have taken place in the belts themselves, it is impossible to determine. That there have been some, we may admit, and rather suppose, but we have no particular reason to suspect them to have been very considerable. And, after we have shewn that a proper motion, in the spots of the belts, of 116 degrees one way, or of 117 the other, would only occasion an error of 2 minutes in time, we need not hesitate to fix the rotation of the planet Saturn upon its axis at $10^h\ 16'\ 0'',4$.

Slough, near Windsor,
Jan. 22, 1794.

WM. HERSCHEL.

Erratum. Phil. Trans. for 1793, Part II, page 215, 2d line, for *more than two degrees and a third,* read 1° 11′ 47″,6.

Fig. 1.

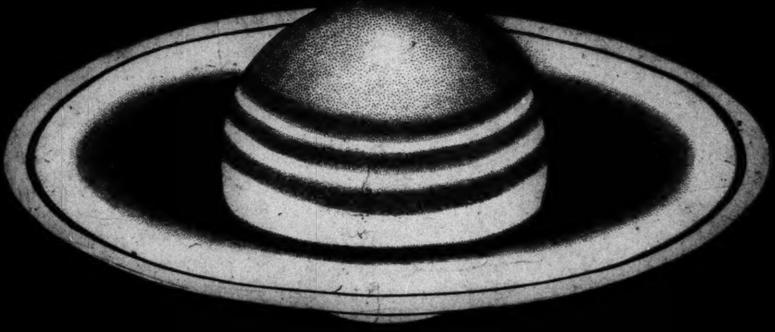


Fig. 2.

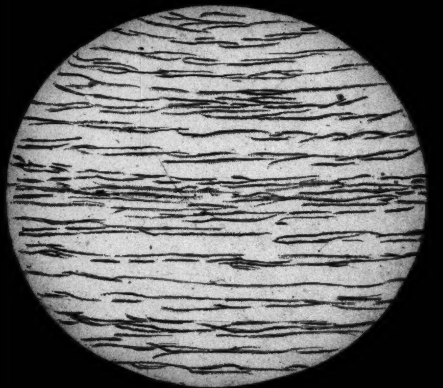
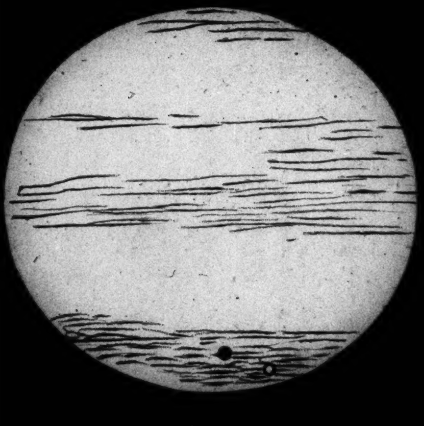


Fig. 3.



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Philos. Trans. MDCCXCIV. *Tab.* VII. *p.* 42.

Fig. 1.

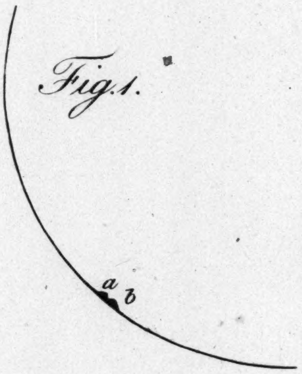


Fig. 2.

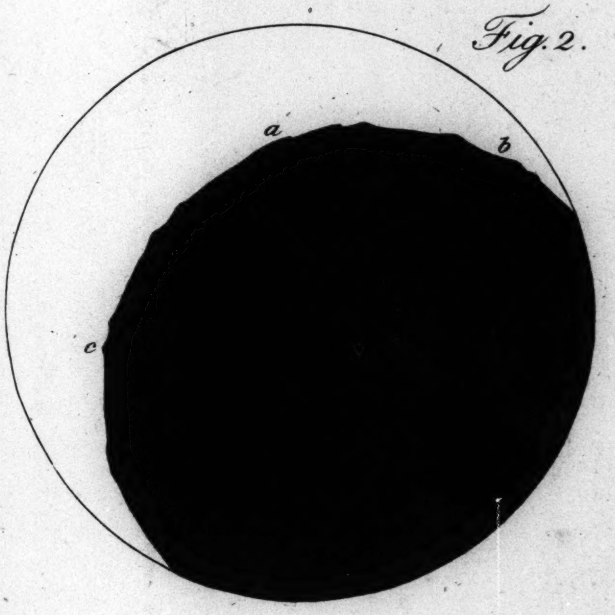


Fig. 3.

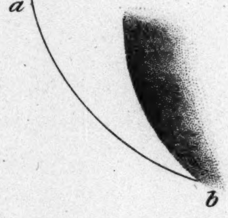
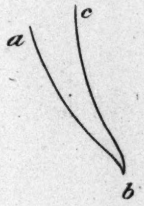


Fig. 4.



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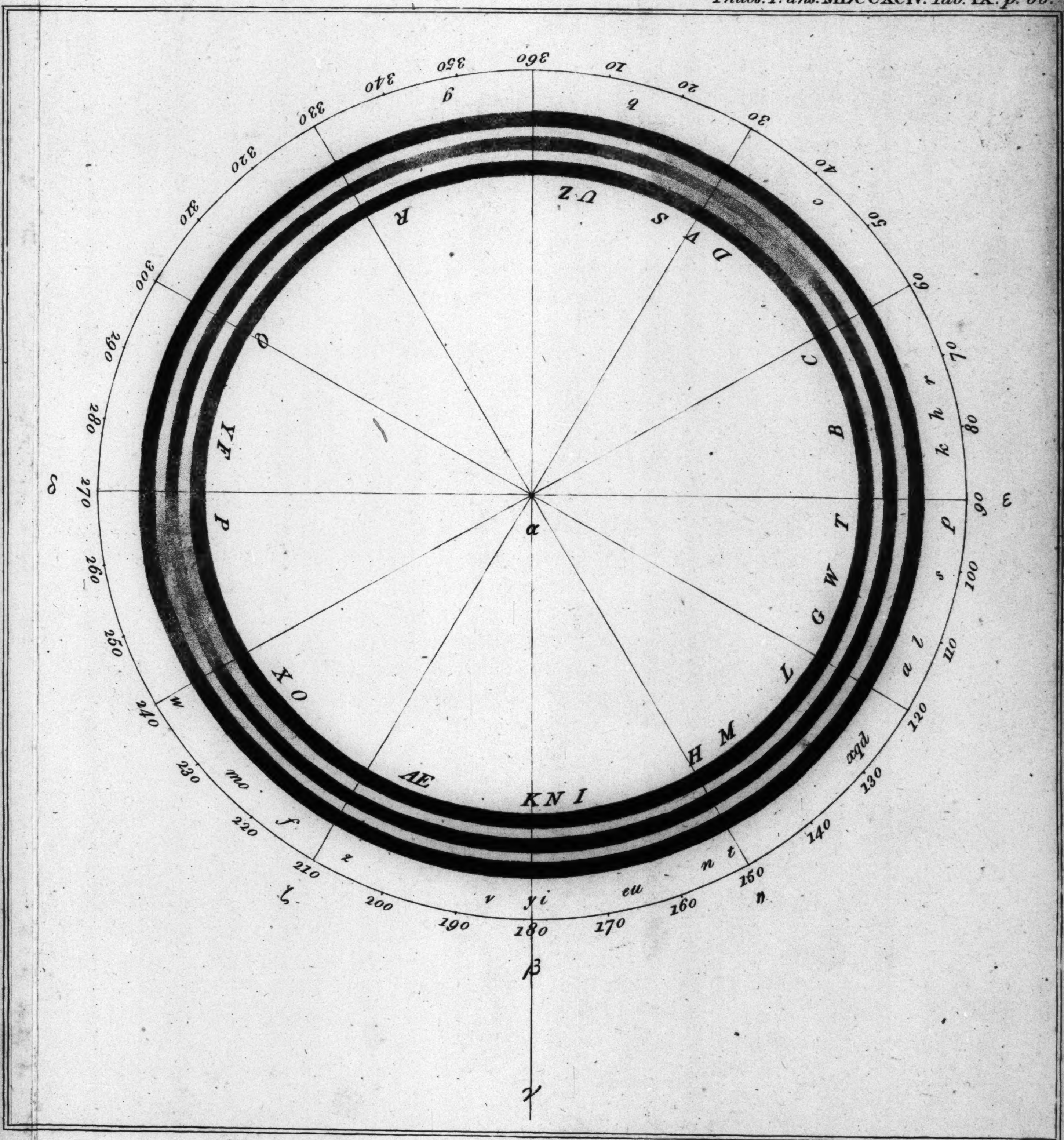
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Basire sc.